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A numerical approach to the syntaxonomy of plant communities of the class *Festuco-Brometea* in Slovakia

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Abstract

Classification of higher level vegetation units (orders and alliances) based on numerical methods often yields different results than traditional plant community classification concepts. We performed a numerical cluster analysis of phytosociological relevés from the class *Festuco-Brometea* in Slovakia with the aim of identifying areas of overlap between the two classification approaches. The research was carried out using a database of approximately 1500 phytosociological relevés sampled in the period between 1927 and 2004. The outputs of the numerical classification form six clusters. Diagnostic taxa of individual clusters were determined using species constancy and fidelity. The cluster analysis enabled us to differentiate the alliances *Seslerio-Festucion pallentis, Diantho lumnitzeri-Seslerion albicantis, Festucion valesiacae, Cirsio-Brachypodion pinnati* and *Asplenio septentrionalis-Festucion pallentis* (incl. *Festucenion pseudodalmaticae*). However, it did not permit the differentiation of the alliances *Koelerio-Phleion phleoidis* and *Bromion erecti.* It also did not allow us to differentiate the orders *Brometalia erecti* and *Festucetalia valesiacae*. The reason for this may be the peripheral occurrence of plant communities of *Brometalia erecti* in Slovakia.

Zusammenfassung: Numerische Syntaxonomie der Pflanzengesellschaften der Klasse *Festuco-Brometea* in der Slowakei

Erstmals wurde eine numerische Analyse von pflanzensoziologischen Aufnahmen der Klasse *Festuco-Brometea* in der Slowakei durchgeführt. Sie versucht, eine Beziehung zwischen der traditionellen Klassifikation von Pflanzengesellschaften höherer Vegetationseinheiten (Ordnungen und Verbände) und einer Klassifikation mit numerischen Methoden zu finden. Insgesamt wurden etwa 1500 Aufnahmen aus dem Zeitraum 1927–2004 analysiert. Die numerische Analyse und Ordination unterscheiden 6 Einheiten, deren diagnostische Arten mit der Hilfe von Stetigkeit und Gesellschaftstreue bestimmt sind. Sie gehören zu folgenden Verbänden: *Seslerio-Festucion pallentis, Diantho lumnitzeri-Seslerion albicantis, Festucion valesiacae, Cirsio-Brachypodion pinnati* und *Asplenio septentrionalis-Festucion pallentis* (incl. *Festucenion pseudodalmaticae*). Die Verbände *Koelerio-Phleion phleoidis* und *Bromion erecti* konnten hingegen nicht abgegrenzt werden.

Keywords: classification, cluster analysis, dry grasslands, *Festuco-Brometea*, phytosociology, xerothermic vegetation.

1. Introduction

The classification of dry grassland communities in Slovakia is problematic. The traditional classification of plant communities of the class *Festuco-Brometea* Br.-Bl. et Tx. ex Klika et Hadač 1944 has until now been based 'only' on the extensive field experience of experts in xerothermic vegetation (MAGLOCKÝ 1981; MUCINA & MAGLOCKÝ 1985). This approach is rather subjective. For instance, in the past only local differences in vegetation types were used as the basis for the description of new syntaxa. The present study tries to support this traditional approach with the formalised numerical analysis of phytosociological relevés and classification of higher level vegetation units (orders and alliances). Dry grassland vegetation in Slovakia, as well as in other countries, responds sensitively to long-term changes related to human impact and management (or the cessation thereof). Along with syntaxonomical studies, it would be important to carry out syndynamic research of successional changes as well.

In the present paper, we focus particularly on the following questions:

1. Is the traditional classification of the class *Festuco-Brometea* at the level of orders and alliances corroborated using numerical methods?
2. What are the diagnostic species that characterise the individual groups/alliances, which are produced as outputs of the numerical classification?
3. Are there any differences in the classification of the class *Festuco-Brometea* in Slovakia compared to other Central European countries, particularly the Czech Republic, Austria and Hungary?

2. Material and methods

The numerical analysis includes about 1500 phytosociological relevés from the class *Festuco-Brometea* stored in the Central Database of Phytosociological Relevés in Slovakia (http://ibot.sav.sk/cdf/index.html). They were sampled in Slovakia during the period 1927–2004 according to the principles of Zürich-Montpellier school (BRAUN-BLANQUET 1964). All accessible published and non-published data were used in the analyses. To obtain data compatible with the numerical classification, all relevés were transformed into the nine-degree ordinal scale (VAN DER MAAREL 1979). Taxa determined only at the level of genus were excluded (except the genera *Alchemilla* and *Taraxacum*).

Some taxonomically problematic species, which were not distinguished by all authors of the relevés, were classified within higher or more broadly defined taxa. These are *Achillea millefolium* (subsp. *millefolium*), *Acosta rhenana* agg. (*Acosta biebersteinii*), *Allium senescens* (subsp. *montanum*), *Anthyllis vulneraria* (subsp. *alpestris*, subsp. *carpatica*, subsp. *polyphylla*, subsp. *vulneraria*), *Biscutella laevigata* (subsp. *hungarica*), *Bromus hordeaceus* (subsp. *hordeaceus*), *Bupleurum falcatum* (subsp. *dilatatum*, subsp. *falcatum*), *Campanula glomerata* (*C. farinosa*), *C. moravica* (subsp. *moravica*, *C. xylorrhiza*), *C. sibirica* (subsp. *divergentiformis*), *Cardaminopsis arenosa* agg. (*C. borbasii, C. halerii, C. petrogena*), *Carlina acaulis* (subsp. *acaulis*), *Cladonia pyxidata* (subsp. *pocillum*), *Caucalis platycarpos* (subsp. *platycarpos*), *Cyanus montanus* (*C. mollis*), *Colymbada scabiosa* agg. (*C. alpestris, C. badensis*), *Cyanus triumfettii* (subsp. *axillaris,* subsp. *strictus*), *Cerastium arvense* (subsp. *calcicolum*), *C. brachypetalum* (subsp. *tauricum*), *Chamaecytisus hirsutus* (subsp. *ciliatus*), *Dactylis glomerata* agg. (*D. polygama*), *Dianthus carthusianorum* (subsp. *latifolius*), *D. praecox* (subsp. *lumnitzeri,* subsp. *praecox*), *Elytrigia intermedia* agg. (*E. trichophora*), *Galium mollugo* agg. (*G. album*), *G. pumilum* agg. (*G. anisophyllon, G. austriacum, G. fatrense*), *Gypsophila fastigiata* (subsp. *arenaria*), *Inula ensifolia* (*Inula ×stricta*), *I. salicina* (subsp. *salicina*), *Jacea pratensis* agg. (*J. macroptilon, J. macroptilon* subsp. *oxylepis, J. pannonica*), *Jovibarba globifera* (subsp. *hirta,* subsp. *tatrensis*), *Laserpitium latifolium* (subsp. *asperum*), *Leontodon hispidus* (subsp. *danubialis,* subsp. *hispidus*), *Leucanthemum vulgare* agg. (*L. ircutianum*), *Molinia* sp. (*M. arundinacea, M. caerulea*), *Papaver dubium* (subsp. *austromoravicum*), *Polygala amara* agg. (subsp. *brachyptera, P. amarella*), *Primula veris* (subsp. *canescens,* subsp. *veris*), *Prunus spinosa* (subsp. *dasyphylla,* subsp. *spinosa*), *Ranunculus acris* (subsp. *strigulosus*), *R. auricomus* agg. (*R. cassubicus*), *Acetosella vulgaris* agg. (*A. tenuifolia*), *Sanguisorba minor* (subsp. *polygama*), *Sempervivum wettsteinii* (subsp. *wettsteinii*), *Silene otites* agg. (subsp. *hungarica*, *S. donetzica*), *S. vulgaris* (subsp. *vulgaris*), *Taraxacum* sp. (*T.* sect. Ruderalia, *T. erythrospermum, T. serotinum*), *Teucrium montanum* (subsp. *jailae,* subsp. *montanum,* subsp. *pannonicum*), *Thalictrum minus* (subsp. *elatum,* subsp. *pseudominus*), *T. simplex* (subsp. *simplex*), *Thymus praecox* (subsp. *praecox*), *T. pulcherrimus* (subsp. *sudeticus*), *Trifolium arvense* (subsp. *gracile*), *T. flexuosum* agg. (*T. sarosiense*), *Viola tricolor* (*V. saxatilis* subsp. *saxatilis*).

Initial data analysis to remove outlier relevés was carried out using the program CANOCO (TER BRAAK & ŠMILAUER 2002). We also excluded some relevés from oversampled areas (relevés with very similar geographical coordinates). However, we tended to keep as many relevés as possible, to be able to track the relevés of individual authors (particularly the authors of the syntaxa descriptions) for comparing the results of cluster analyses with the authors' classification of the relevés at the level of higher vegetation units. For the cluster analyses we used relevés distributed throughout the territory of Slovakia. Numerical cluster analyses were performed using the HIERCLUS program from the package SYN-TAX 2000 (PODANI 2001). The β-flexible method (β = –0.25) with Euclidean distance, Wishart similarity coefficient and Jaccard similarity coefficient were used. The results were evaluated by comparison and analysis of phytosociological tables processed by the FYTOPACK program (JAROLÍMEK & SCHLOSSER 1997).

Table 1 contains the outputs of the numerical classification in the form of clusters. The individual clusters contain the number of relevés and the average number of species in the relevant relevé group. Each of the six clusters (designated alphabetically A–F) includes two parts (c and f). The 'c' characterises the taxa by their constancy (in %; + = constancy < 0.5 %) and the mean value of abundance (upper index, in ordinal scale) calculated with FYTOPACK, while 'f' shows the fidelity as the *phi* coefficient multiplied by 100. Diagnostically important taxa of individual clusters were determined by calculating constancy and fidelity of each species to each cluster, using the *phi* coefficient of association in the program Juice 6.1 (TICHÝ 2002). These taxa are given in bold. We defined diagnostic species as those species whose frequency in a vegetation unit was at least two frequency classes higher than in other vegetation units (BERGMEIER et al. 1990). For more precise information, we used particular percentage values instead of the frequency classes. In some cases, when the threshold value of species constancy did not achieve the 'rule of difference in two frequency classes', we combined it with the fidelity value. We did this because, according to TICHÝ, 'the constancy of a species shows the liable frequency of its occurrence in a group, but it does not represent its diagnostic weight. On the other hand, the fidelity value might be high also for the species, which are strictly linked with a particular syntaxon, although its constancy is relatively low. Constancy and fidelity cannot substitute each other. It is very convenient to combine them into a synoptic table' (TICHÝ 2004, TICHÝ & HOLT 2006). A map of relevé locations accompanies each cluster (Fig. 1–6). The maps were created using the program DMAP (MORTON 2005).

The sources of individual relevés, sorted according to particular clusters, are given in alphabetical order in Appendix 1. The information includes number of relevés; author and year in which the relevés were published; brief references (in brackets; for unpublished data only the names of authors are given); table(s) and relevé(s) sequence; and finally, orographical unit within the study area.

The nomenclature of the taxa follows MARHOLD & HINDÁK (1998). In Table 1, the designations of the diagnostic taxa of classes and lower syntaxa follow CHYTRÝ & TICHÝ (2003), MUCINA et al. (1993), HOLUB et al. (1967) and partly also MAGLOCKÝ (1985, mscr.).

3. Results

We obtained almost identical numerical classification results through the application of three different algorithms, namely the β-flexible method with Euclidean distance, the Wishart similarity coefficient and Jaccard similarity coefficient. Comparing the results of the different classifications, we have decided to consider the application of the Wishart coefficient as the most appropriate. Using this coefficient, the differentiation of the clusters was closely related to the view of the classic authors of syntaxa descriptions. Interpreting the results, we have applied the third highest level of dissimilarity. The individual clusters of the dendrogram pertained to concrete, floristically and ecologically well-defined groups (Table 1).

3.1. Cluster A: *Carex humilis*-rich group (Fig. 1)

This cluster comprises relevés of *Carex humilis*-dominated associations. These dense grasslands occur on sites with relatively deep soils (in comparison with cluster B). The presence of thermophilous species (*Allium flavum, Melica ciliata, Potentilla arenaria, Pulsatilla grandis, Rhodax canus, Stipa joannis, S. pulcherrima*) differentiates this type of vegetation (belonging to the class *Festuco-Brometea*) from dry grasslands also dominated by *Carex humilis* occurring at higher altitudes (belonging to the class *Elyno-Seslerietea* Br.-Bl. 1948, alliance *Astero-Seslerion calcariae* Hadač ex Hadač et al. 1969, suballiance *Pulsatillo slavicae-Caricenion humilis* Uhlířová in Kliment et al. 2005; cf. KLIMENT et al. 2005). The different ecological conditions of the inner-Carpathian basins and adjacent slopes of the surrounding mountains have a strong influence on the floristic configuration of the vegetation dominated by the same grass species (KLIMENT & BERNÁTOVÁ 2004).

3.2. Cluster B: *Festuca pallens*-rich group (Fig. 2)

This group includes open vegetation of rock outcrops dominated by the grass *Festuca pallens*, which occurs on extreme sites with thin, discontinuous soils. *Festuca pallens* prefers sunny, rocky sites most frequently on basic to neutral soils (DOSTÁL & ČERVENKA 1991, 1992). There are some floristic similarities to the cluster A (co-occurrence of *Potentilla arenaria, Poa badensis, Stipa pulcherrima, Silene otites* and *Pulsatilla grandis*) but ecological and physiognomic differences are clear.

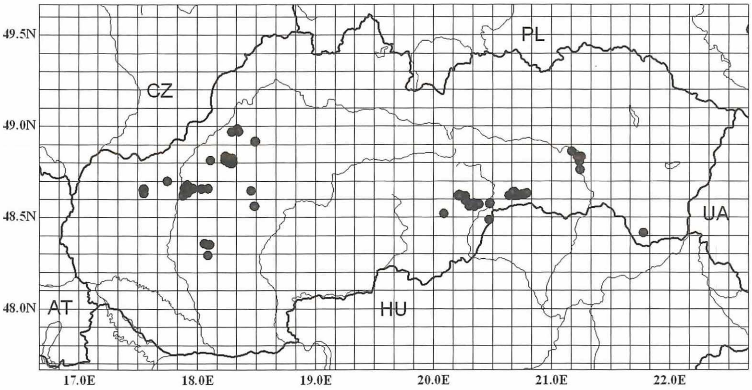

Fig. 1: Location of relevés belonging to the cluster A.

Abb. 1: Lage der einzelnen Aufnahmeflächen des Clusters A.

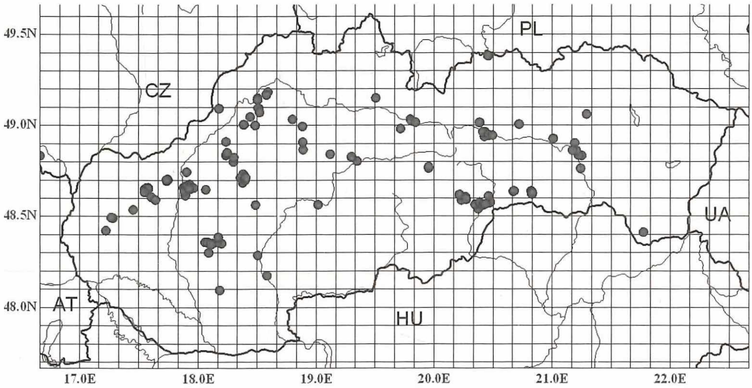

Fig. 2: Location of relevés belonging to the cluster B.

Abb. 2: Lage der einzelnen Aufnahmeflächen des Clusters B.

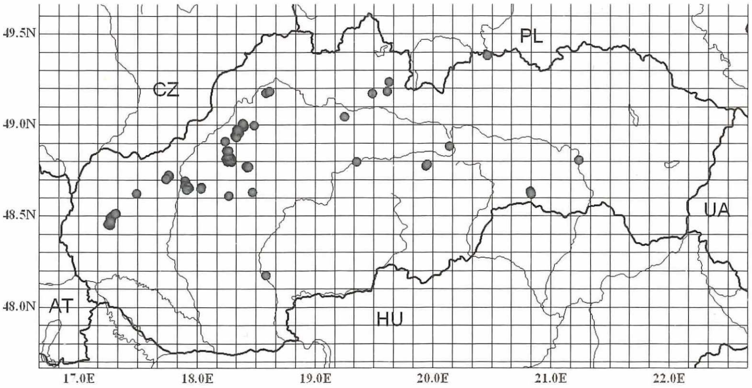

Fig. 3: Location of relevés belonging to the cluster C.

Abb. 3: Lage der einzelnen Aufnahmeflächen des Clusters C.

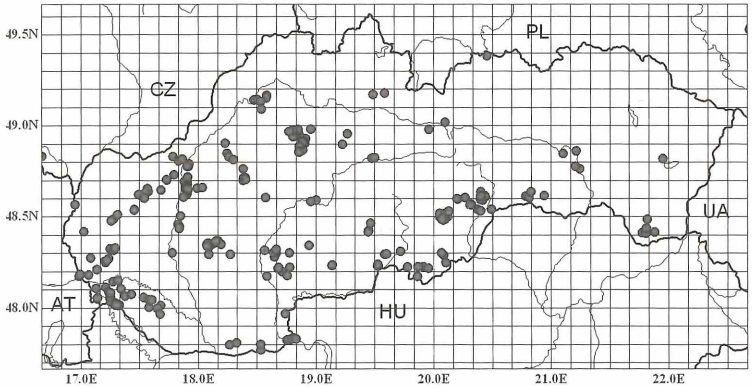

Fig. 4: Location of relevés belonging to the cluster D.

Abb. 4: Lage der einzelnen Aufnahmeflächen des Clusters D.

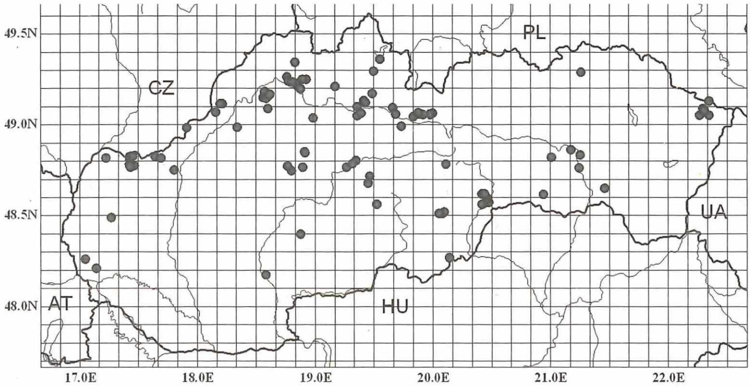

Fig. 5: Location of relevés belonging to the cluster E.

Abb. 5: Lage der einzelnen Aufnahmeflächen des Clusters E.

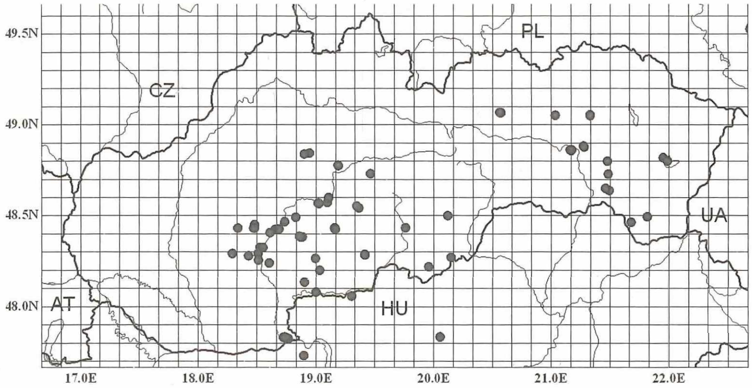

Fig. 6: Location of relevés belonging to the cluster F.

Abb. 6: Lage der einzelnen Aufnahmeflächen des Clusters F.

3.3. Cluster C: *Diantho lumnitzeri-Seslerion albicantis* (Soó 1971) Chytrý et Mucina in Mucina et al. 1993 (Fig. 3)

This group includes basiphilous meso- to xerophilous grassland vegetation of rocky outcrops, typically dominated by *Sesleria albicans* and *Carex humilis*. Prae-alpine (*Acinos alpinus, Asperula tinctoria, Leontodon incanus*) and de-alpine species (e.g., *Sesleria albicans*) are present as well as some colline and lowland species (e.g., *Tephroseris integrifolia*). This grassland type occurs at lower altitudes in the mountains or in inversion sites. The occurrence of mountain species (*Acinos alpinus, Biscutella laevigata, Hippocrepis comosa, Kernera saxatilis, Knautia kitaibelii, Phyteuma orbiculare, Pulsatilla slavica, Thesium alpinum*) points to close syngenetic relationships to the mountain plant communities of the suballiance *Pulsatillo slavicae-Caricenion humilis* (cf. KLIMENT et al. 2005).

3.4. Cluster D: *Festucion valesiacae* Klika 1931 (Fig. 4)

These narrow-leaved xerophilous steppe grasslands on calcareous substrates and loess occur at low altitudes in the basins of Western Carpathians and in the prae-Carpathian area (the southern foothills of the Western Carpathian mountain range). The grass species *Festuca valesiaca* and *F. rupicola* are dominant. This cluster has the highest concentration of xerophilous plant species within the data set. Some endemic taxa are present (e.g., *Astragalus vesicarius* subsp. *albidus*, *Carduus collinus* subsp. *collinus*, *Jurinea mollis* subsp. *macrocalathia*, *Linum hirsutum* subsp. *glabrescens*, *Lotus borbasii*, *Onosma arenarium*, *O. tornense*, *Ophrys holubyana*, *Peucedanum arenarium*, *P. zimmermannii*, *Taraxacum slovacum*, *Thlaspi jankae*, etc.; KLIMENT 1999). *Festucion valesiacae* occurs naturally on shallow soils where no forest growth is possible. However, it also secondarily colonizes open sites created by deforestation, where grasslands have been maintained by grazing (CHYTRÝ et al. 2006). A consistent decline in the number of suitable sites (ploughing of the loess soils, cessation of grazing management) has led to the present mosaic pattern in the distribution of this vegetation type. Cessation of grazing leads to successional changes in the vegetation and invasion of species from surrounding vegetation types.

3.5. Cluster E: *Cirsio-Brachypodion pinnati* Hadač et Klika ex Klika 1951 (Fig. 5)

These are meso- to xerophilous, subcontinental meadow-steppe communities dominated by *Brachypodium pinnatum*. Cluster E is a very well differentiated group, characterised by 60 diagnostic species. Six of them are identical with those mentioned by MUCINA & KOLBEK (1993), e.g., *Brachypodium pinnatum, Carlina vulgaris, Cirsium pannonicum, Jacea pratensis* agg., *Polygala major*, and *Ranunculus polyanthemos.* Many of them are also diagnostic species of the class *Molinio-Arrhenatheretea* R. Tx. 1937 (see Table 1), which shows close syndynamic relationships to this phytosociological unit. In Slovakia they are found in basins and foothills of mountains formed of crystalline rocks as well as on flysch (STANOVÁ & VALACHOVIČ 2002).

3.6. Cluster F: *Asplenio septentrionalis-Festucion pallentis* Zólyomi 1936 corr. 1966 (incl. *Festucenion pseudodalmaticae* Klika 1955) (Fig. 6)

These are sub-pannonic dry steppe grasslands of Tertiary vulcanite bedrocks. The dominant tussock grass is *Festuca pseudodalmatica*. The unit is distributed in the Neogene volcanic mountain region of central, southern and eastern Slovakia. Neogene volcanic substrates include basalt (basic pH reaction), rhyolite (acidic pH reaction) and andesite (basic to acidic, dependent on the amount of calcium). The variation in parent material is reflected in the occurrence of neutro- to basiphilous species (*Erysimum crepidifolium, Hylotelephium maximum, Lactuca viminea, Melica transsilvanica, Poa pannonica, Stachys recta, Thymus pannonicus*), acidophilous species (*Asplenium septentrionale, Festuca pseudodalmatica, Filago arvensis, Inula oculus-christi*) and calcifuge species (*Petrorhagia prolifera, Potentilla argentea*).

4. Discussion and conclusions

The comparison of traditional deductive classification methods with the numerical approach highlights several important considerations. We shall first of all consider the implications of this comparison for communities traditionally classified within the order *Festucetalia valesiacae*, and then examine the consequences of our analysis for the order *Brometalia erecti*.

First, the syntaxonomy of clusters A and B (*Carex humilis*-rich group and *Festuca pallens*-rich group) is difficult. Both of them include many differential species of *Seslerio-Festucion pallentis* as well as *Festucion valesiacae*. The majority of relevés included in cluster A were classified by their original authors as belonging to the alliance *Seslerio-Festucion pallentis* Klika 1931 corr. Zólyomi 1966, while a smaller number were placed within the *Festucion valesiacae* Klika 1931. The ecology and distribution of the relevés analysed suggests that the relationship to *Seslerio-Festucion pallentis* is stronger. The analysis shows there is more likely no need to classify *Carex humilis*-dominated plant communities within two separate alliances. Cluster B includes, but is not limited to, relevés of circumpannonian thermophilous grasslands on calcareous bedrock, occurring at the foothills of the Western Carpathians (the 'Praecarpaticum'). In Austria and Hungary, this vegetation is classified within the alliance *Bromo pannonici-Festucion pallentis* Zólyomi 1966 (MUCINA & KOLBEK 1993, BORHIDI & SÁNTA 1999). We suspect that this vegetation type, which is certainly present in southern Slovakia, would be differentiated in a separate cluster if we were to include data from Austria and Hungary in the analysis. Without these data, the results of the analysis show that the dominance of *Festuca pallens* is a more important factor for the differentiation of the cluster than the presence or absence of any circumpannonian thermophilous species. For the purpose of the present study, we suggest assigning the vegetation of clusters A and B to a relatively broadly defined alliance *Seslerio-Festucion pallentis* (see Fig. 7). The content of this name has admittedly changed in the history of phytosociology and it is often considered (e.g., by MUCINA & KOLBEK 1993) to be a 'nomen ambiguum' according to article 36 of the Code of Phytosociological Nomenclature (WEBER et al. 2000). To be able to solve the nomenclatural problems, it is necessary to analyse a larger data set using data from other central European countries.

Our second observation on the syntaxonomy of dry grasslands pertains to the alliance *Asplenio septentrionalis-Festucion pallentis*. The original concept of *Asplenio septentrionalis-Festucion pallentis* included not only stands on vulcanite bedrock but also on serpentine (*Asplenio-Festucion glaucae* Serpentingruppe; cf. ZÓLYOMI 1936). This may be the reason why KLIKA (1955) described the suballiance *Festucenion pseudodalmaticae* Klika 1955, although he classified it within *Seslerio-Festucion duriusculae* Klika 1931 (syn.: *Seslerio-Festucion pallentis*; see Fig. 7). MICHALKO (1957) accepted the suballiance, but on the basis of species composition and occurrence on relatively deeper soils, considered it part of the *Festucion valesiacae*. KLIMENT et al. (2000) classified an association dominated by *Festuca pseudodalmatica* on vulcanite bedrock (*Potentillo arenariae-Festucetum pseudodalmaticae* Májovský 1955) within the alliance *Festucion valesiacae* for the same reasons, in agreement with MÁJOVSKÝ (1955), SOÓ (1959, 1964, 1973, 1980) and BORHIDI (1996). Our numerical analysis shows that the xerophilous vegetation on Tertiary vulcanite bedrock is in fact more closely related to the vegetation of the *Festucion valesiacae* (cluster D) than to any of the clusters which we consider to be representatives of *Seslerio-Festucion pallentis* (clusters A, B; see dendrogram in Table 1). At the same time, the vegetation on Tertiary vulcanite bedrock comes out well differentiated from the other clusters. We thus consider it to be reasonable to recognize *Asplenio septentrionalis-Festucion pallentis* as its own alliance (instead of as a suballiance, *Festucenion pseudodalmaticae*). *Asplenio septentrionalis-Festucion pallentis* Zólyomi 1936 corr. 1966 (incl. *Festucenion pseudodalmaticae* Klika 1955) can thus be considered a vicariant alliance to *Alysso saxatilis-Festucion pallentis* Moravec in Holub et al. 1967, which occurs in the western part of central Europe (Czech Republic, Austria; MUCINA & KOLBEK 1993).

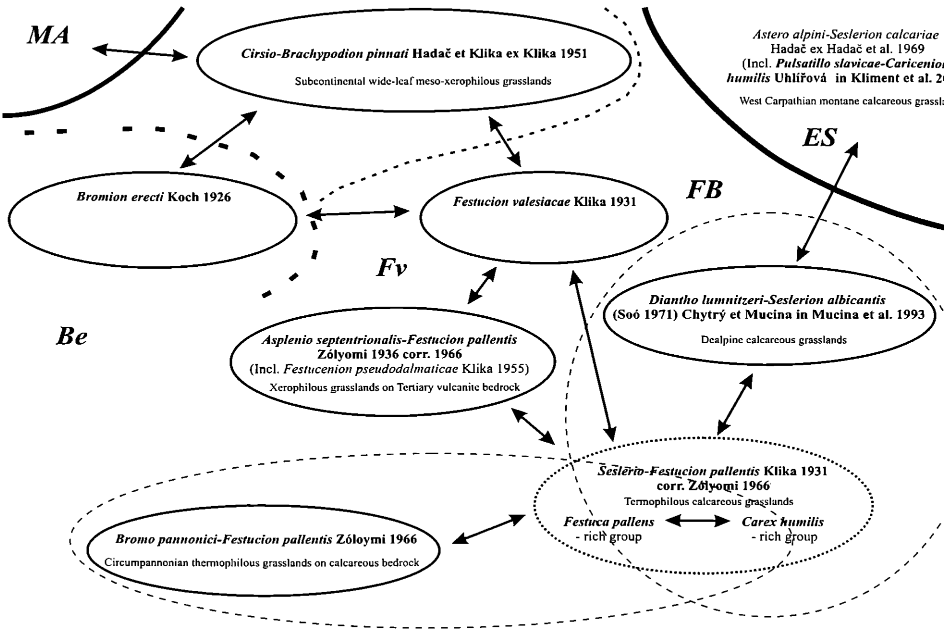

Fig. 7: Syntaxonomical scheme of higher vegetation units of the class *Festuco-Brometea* in Slovakia. Arrows indicate dynamic or syngenetic relationships between individual syntaxa. Thick lines separate the class *Festuco-Brometea* (*FB*) from *Elyno-Seslerietea* (*ES*) and *Molinio-Arrhenatheretea* (*MA*); the dashed thick line separates the order *Brometalia erecti* (*Be*) from *Festucetalia valesiacae* (*Fv*). The thinner dashed line indicates the amphibolous classification of the alliance *Cirsio-Brachypodion pinnati* into different orders. The dotted ellipse stands for the alliance *Seslerio-Festucion pallentis* that partially corresponds with alliances *Bromo-Festucion pallentis* and *Diantho-Seslerion albicantis* (dashed ellipses).

Abb. 7: Syntaxonomisches Schema der höheren Vegetationseinheiten der *Festuco-Brometea* in der Slovakei.

The classification of *Cirsio-Brachypodion pinnati* within the higher vegetation units is likewise ambiguous (CHYTRÝ et al. 2006; see Fig. 7). It is classified within the order *Brometalia erecti* by some authors (MUCINA & KOLBEK 1993; HOLUB et al., 1967). Other authors (MUCINA & MAGLOCKÝ 1985, KLIKA 1955) have considered it to be a part of the order *Festucetalia valesiacae*. According to the numerical analysis, the closest relevé group to *Cirsio-Brachypodion pinnati* is that of the *Festucion valesiacae* (see dendrogram in Table 1). The numerical classification would thus tend to support its assignment to the order *Festucetalia valesiacae*.

Our attempt to differentiate the two orders of the class *Festuco-Brometea* (*Festucetalia valesiacae* Br.-Bl. et R. Tx. 1943 and *Brometalia erecti* Br.-Bl. 1936) conventionally distinguished in Slovak phytosociological literature (MUCINA & MAGLOCKÝ 1985) was not successful. In general, plant communities traditionally considered to belong to the continental to continental-sub-Mediterranean order *Festucetalia valesiacae* are well developed in Slovakia. Based on the cluster analysis, we differentiated five alliances of this order: *Seslerio-Festucion pallentis*, *Diantho lumnitzeri-Seslerion albicantis*, *Festucion valesiacae*, *Cirsio-Brachypodion pinnati* and *Asplenio septentrionalis-Festucion pallentis* (incl. *Festucenion pseudodalmaticae*). Each alliance is well characterised by diagnostic species (Table 1).

In contrast to the *Festucetalia valesiacae*, relevés of *Brometalia erecti* and *Bromion erecti* Koch 1926 did not form a separate cluster but dispersed in the clusters D and E (22 relevés classified within these units according to their original authors, e.g. KLIMENT et al. 2000: Tab. 3, rel. 22, 23; KRIPPELOVÁ 1967: Tab. 10, rel. 1-8; KLIKA 1929: p. 42, rel. 1; MÁJOVSKÝ

1958: p. 370, rel. 1; JURKO 1971; see Appendix 1). The sub-Atlantic vegetation of the order *Brometalia erecti* is present in Slovakia only in fragments because of its decreasing abundance in the sub-continental parts of central Europe. Some authors have not distinguished the alliance *Cirsio-Brachypodion pinnati* from the *Bromion erecti* (CHYTRÝ & TICHÝ 2003) or have substituted them. We do not think the vegetation units *Cirsio-Brachypodion pinnati* and *Bromion erecti* can be substituted or combined, as the two vegetation types exhibit clear discrepancies in their floristic composition in central and western Europe (e.g., Switzerland; cf. KOCH 1926). The definitive classification of these vegetation types in Slovakia within orders and alliances (*Cirsio-Brachypodion pinnati, Bromion erecti, Festucetalia valesiacae, Brometalia erecti*) should be solved by analysis and comparison of a well selected and representative data set (using stratified resampling of phytosociological databases; cf. KNOLLOVÁ et al. 2005) including relevés of Atlantic, sub-Atlantic, sub-Mediterranean, sub-continental and continental xerophilous vegetation types (MICHÁLKOVÁ et al., in prep.).

The cluster analysis also did not differentiate the alliance *Koelerio-Phleion phleoidis* Korneck 1974. This dry grassland vegetation type occurs on silicate substrates poor in minerals in only a small area of Slovakia (Malé Karpaty Mountains). Accordingly only a small number of relevés (25) was available, which might be the main reason for the alliance not being differentiated. The relevés classified within *Koelerio-Phleion phleoidis* by the original authors (CHYTRÝ et al. 1997; ZLINSKÁ 2000) occur in the cluster D (see Appendix 1). They were not directly grouped together, but some relationship between them was indicated. For the differentiation of the alliance *Koelerio-Phleion phleoidis* it would be necessary to analyse a number of relevés comparable to the rest of the analysed data set, using also data from neighbouring central European countries.

The diagnostic species of groups/alliances derived from this numerical classification are relatively different from those published by CHYTRÝ & TICHÝ (2003). We identified five of the same diagnostic species in the clusters A and B, which might be generally called *Seslerio-Festucion pallentis*. These are *Alyssum montanum, Festuca pallens, Jovibarba globifera* subsp. *hirta, Poa badensis* and *Sedum album.* We also identified six of the same diagnostic species of the alliance *Festucion valesiacae* (*Adonis vernalis, Botriochloa ischaemum, Festuca rupicola, F. valesiaca, Koeleria macrantha* and *Phleum phleoides*). The rest of the vegetation units do not occur in the Czech Republic or if they do, they are classified following a different concept. The difference in the diagnostic species is most likely a result of the large differences in bedrock geology and evolution of plant communities in Slovakia and the Czech Republic. The Carpathian Mountains altogether with the contact area of the prae-Carpathian and Pannonian regions cover the majority of Slovakia. They combine to create a highly unique flora, which is reflected in the phytosociological characterisation of grassland vegetation.

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Appendix 1: Sources of relevés

Cluster A:

24 – Baňacká 1982 (Master thesis, mscr.): Tab. 3, rel. 1-17, 19-25, Slovenský kras Karst, Drieňovec; 1 – Domin 1932 (Rozpr. II. Tr. Čs. Akad.): Tab. 1, rel. 6, Malé Karpaty Mtns., Čachtické kopce Hills; 3 – Eliáš 1988 (Rosalia): Tab. 1, rel. 1-3, Tríbeč Mtns.; 1 – Fajmonová 1995 (Naturae Tutela): Tab. 1, rel. 4, Strážovské vrchy Mtns.; 4 – Fajmonová ined.: Strážovské vrchy Mtns.; 30 – Futák 1947 (Sp. Sv. Vojtecha): Tab. 1, rel. 1-5, 7-30, p. 87, rel.10, Strážovské vrchy Mtns., Kňaží stôl Mt.; 15 – Futák 1960 (PhD. thesis, mscr.): Tab. 1, rel. 1, 2, 4, 5, 8-15, p. 79, rel. 7, p. 106, rel.1, 2, Strážovské vrchy Mtns.; 7 –

Háberová et al. 1985 (Final report, mscr.): Tab. 3, rel. 5-11, Slovenský kras Karst; 1 Jurko 1951 (SAVU): p. 28, rel. 1, Čierna hora Mtns.; 4 – Klika 1937 (Beih. Bot. Centralbl.): p. 301, rel. 1, Tab. 1, rel. 11-13, Malé Karpaty Mtns., Brezovské kopce Hills; 17 – Kliment 1978 (Master thesis, mscr.): Tab. 4, rel. 1-16, 19, Revúcka vrchovina Hills; 12 – Kliment ined.: Slovenský kras Karst, Jelšavský kras Karst; 20 – Maglocký 1979 (Biol. Pr.): Tab. 26, rel. 1-10, 13-15, 18-24, Považský Inovec Mtns.; 14 – Miadok 1987 (Acta Fac. Rer. Nat. Univ. Comen.): Tab. 2, rel. 1-14, Slovenský kras Karst, Koniarska planina Plateau; 3 – Maglocký ined.: Zemplínske vrchy Hills (1), Čierna hora Mtns. (2); 35 – Pavlíková 1981 (Master thesis, mscr.): Slovenský kras Karst, Horný vrch Mt; 1 – Sitášová 2000 (Natura Carpatica): p.139, rel. 12, Čierna hora Mtns.; 1 – Sitášová 2002: p. 62, rel. 4, Čierna hora Mtns.; 1 – Sitášová & Kaduková 1997: p. 30, rel. 2, Čierna hora Mtns.; 3 – Valachovič, ined.: Považský Inovec Mtns., Tematínske kopce Hills; 1 Vološčuk 1987: Slovenský kras Karst; 8 – Vozárová 1986 (Zborn. Slov. Nár. Múz.): Tab. 2, rel. 1-8, Tríbeč Mtns., Zobor Hills;

Cluster B:

9 – Baláž 1991 (Master thesis, mscr.): Tab. 2, rel. 1-9, Nízke Tatry Mtns.; 8 – Baňacká 1982 (Master thesis, mscr.): Tab. 2, rel. 1-7, Tab. 3, rel. 26, Slovenský kras Karst; 3 – Bosáčková et al.1974 (In: Štollmann A., ed., Osveta): Tab. 2, rel. 1-3, Strážovské vrchy Mtns., Súľovské vrchy Hills; 7 – Domin 1932 (Rozpr. II. Tr. Čs. Akad.): p. 7, rel. 1, p. 8, rel. 1, Tab. 1, rel. 1-5, Malé Karpaty Mtns., Čachtické kopce Hills; 2 – Duchoslav & Gruna 1995 (Zpr. Čes. Bpt. Společn.): rel. 1, 2, Strážovské vrchy Mtns.; 1 – Eliáš 1988 (Rosalia): p. 71, rel. 3, Tríbeč Mtns.; 6 – Fajmonová ined.: Malé Karpaty Mtns.; 20 – Futák 1947 (Sp. Sv. Vojtecha): Tab. 1, rel, 6, 31-45, p. 85, rel. 3, 4a, 4b, p. 86, rel. 5, 6, p. 87, rel. 11, Strážovské vrchy Mtns., Kňaží stôl Mt.; 5 – Futák 1960 (PhD. thesis, mscr.): rel. 12, 14, 15, Tab. 1, rel. 6, 7, Strážovské vrchy Mtns.; 8 – Háberová et al.1985 (Final report, mscr.): Tab. 3, rel. 1-4, 12-15, Slovenský kras Karst; 2 – Jarolímek ined.: Malé Karpaty Mtns.; 9 – Jurko 1951 (SAVU): Tab. 1, rel. 1-5, 7-10, Čierna hora Mtns.; 4 – Klika 1930 (Příř. Spol. v M. Ostravě): p. 53, rel. 1, Tab. 1, rel. 3, Tab. 3, rel. 15, 18, Strážovské vrchy Mtns., Manínska tiesňava Gorge; 8 – Klika 1929 (Preslia): p. 44, rel. 1-8, Turčianska kotlina Basin; 5 – Klika 1931 (Beih. Bot. Centralbl.): p. 361, rel. 10 (Malé Karpaty Mtns.), p. 363, rel. 12-15 (Považský Inovec Mtns., Tematínske kopce Hills); 7 – Klika 1936 (Sb. Čs. Akad. Zeměd.): p. 334, rel. 3, Tab. 1, rel. 1-6, Malé Karpaty Mtns., Čachtické kopce Hills; 11 – Klika 1937 (Beih. Bot. Centralbl.): p. 302, rel. 2, p. 303, rel. 1, 2, Tab. 1, rel. 1, 3-8, 10, Malé Karpaty Mtns., Brezovské kopce Hills; 4 – Kliment 1978 (Master thesis, mscr.): Tab. 4, rel. 17-21, Revúcka vrchovina Hills; 2 – Kliment ined.: Slovenský kras Karst, Jelšavský kras Karst; 2 – Kliment & Bernátová 2000 (Kmetianum): Tab. 1, rel. 12, 13, Spišská kotlina Basin; 3 – Kochjarová 1998 (PhD. thesis, mscr.): Tab. 1, rel. 10, Tab. 2, rel. 4 (Strážovské vrchy Mtns.), p. 77, rel. 6 (Slovenský kras Karst); 19 – Maglocký 1979 (Biol. Pr.): Tab. 22, rel. 1-19, Považský Inovec Mtns.; 1 – Maglocký ined.: Ipeľská pahorkatina Hills; 10 – Miadok 1987 (Acta Fac. Rer. Nat. Univ. Comen.): Tab. 1, rel. 1-10, Slovenský kras Karst, Jelšavský kras Karst; 6 – Michálková 2003 (Master thesis, mscr.): Tab. 10, rel. 16, 20, Tab. 11, rel. 1, 2, p. 43, rel. 1, p. 46, rel. 2, Strážovské vrchy Mtns.; 4 – Mucina ined.: Hornádska kotlina Basin(1), Nízke Tatry Mtns. (2), Veľká Fatra Mtns. (1); 11 – Pitoniak et al. 1978 (Biol. Pr.): Tab. 4, rel. 1-11, Slovenský raj Mtns.; 1 – Ripka ined.: Spišsko-šarišské medzihorie Hills; 2 – Sitášová 2000 (Natura Carpatica): p. 140, rel. 13, 14, Čierna hora Mtns.; 1 – Sitášová 2002 (Natura Carpatica): p. 63, rel. 5, Čierna hora Mtns.; 2 – Sitášová & Kaduková 1997 (Natura Carpatica): p. 31, rel. 1, 2, Čierna hora Mtns.; 5 – Szaboóvá-Baxandale 1994 (Master thesis, mscr.): Tab. 4, rel. 1-5, Slovenský kras Karst, Zádielska dolina Valley; 1 – Šmarda 1961 (SAV): p. 50, rel. 1, Spišská kotlina Basin; 4 – Šmarda 1970 (Pr.Stud. Cs. Ochr. Prir. SUPSOP): Tab. 3, rel. 1–4, Slovenský raj Mtns.; 20 – Valachovič 1981 (Master thesis, mscr.): p. 24, rel. 1-8, p. 35, rel. 1-12, Slovenský kras Karst, Zádielska dolina Valley; 33 – Valachovič ined.: Biele Karpaty Mtns. (2), Kremnické vrchy Mtns. (1), Malé Karpaty Mtns. (10), Muránska planina Mtns. (2), Nízke Tatry Mtns. (5), Pavlovské vrchy Mtns. (5), Pieniny Mtns. (2), Strážovské vrchy Mtns. (5), Považský Inovec Mtns., Tematínske kopce Hills (1); 1 – Vološčuk 1987: Slovenský kras Karst; 36 – Vozárová 1986 (Zb. Slov. Nár. Múz. Prír. Vedy): Tab. 1, rel. 1-27, Tab. 2, rel. 9-14, Tab. 3, rel. 36-38, Tríbeč Mtns., Zobor Hills; 1 – Vozárová 1990 (Zb. Slov. Nár. Múz. Prír. Vedy): Tab. 1, rel. 3, Štiavnické vrchy Mtns.;

Cluster C:

7 – Baláž ined.: Horehronské podolie Basin; 3 – Domin 1931 (Věda Přír.): p. 119, rel. 1, 2, p. 120, rel. 3, Malé Karpaty Mtns.; 1 – Domin 1932 (Rozpr. II. Tr. Čs. Akad.): p. 10, rel. 1, Malé Karpaty Mtns., Čachtické kopce Hills; 13 – Fajmonová 1995 (Naturae Tutela): Tab.1, rel. 1-3, 5-14, Strážovské vrchy Mtns.; 34 – Fajmonová ined.: Strážovské vrchy Mtns.; 11 – Futák 1947 (Sp. Sv. Vojtecha): Tab. 2, rel. 1-11, Strážovské vrchy Mtns., Kňaží stôl Mt.; 20 – Futák 1960 (PhD. thesis, mscr.): Tab. 1, rel. 3. Tab 1a,

rel. 1-8, Tab. 2, rel. 1-10, p. 92, rel. 1, Strážovské vrchy Mtns.; 1 – Jarolímek ined.: Malé Karpaty Mtns.; 1 – Jurko 1951 (SAVU): p. 28, rel. 2, Čierna hora Mtns.; 11 – Klika 1928 (Sb. Přír. Spol. v M. Ostravě): Tab. 1, rel. 2-6, Tab.3, rel. 14-22, Strážovské vrchy Mtns., Súľovské vrchy Hills; 2 – Klika 1931 (Beih. Bot. Centralbl.): p. 369, rel. 25, 26 (Malé Karpaty Mtns.), p. 370, rel. 29 (Považský Inovec Mtns.); 2 – Klika 1936 (Sb. Čs. Akad. Zeměd.): p. 334, rel. 1, 2, Malé Karpaty Mtns., Čachtické kopce Hills; 9 – Kochjarová 1998 (PhD. thesis, mscr.): Tab. 1, rel. 6-8, 11, 12, Tab. 5, rel. 5-7, p. 77, rel. 5, Strážovské vrchy Mtns.; 33 – Maglocký 1979 (Biol. Pr.): Tab. 25, rel. 1, 4, 5, 7-9, 14 (Malé Karpaty Mtns.), Tab. 23, rel. 1-3, Tab. 25, rel. 2, 3, 6, 10, 12, 13, 15-18, 22-25 (Považský Inovec Mtns.), Tab. 25, rel. 11, 19, 25-30 (Strážovské vrchy Mtns.); 7 Michálková 2003 (Master thesis, mscr.): Tab. 10, rel.17-19, 21-24, Strážovské vrchy Mtns.; 1 – Mucina ined.: Chočské vrchy Mtns.; 9 – Valachovič 1981 (Master thesis, mscr.): Tab. 5, rel. 1-8, 13, Slovenský kras Karst; 16 – Valachovič ined.: Malé Karpaty Mtns. (8), Muránska planina Mtns. (2), Pieniny Mtns. (2), Strážovské vrchy Mtns. (2), Veľká Fatra Mtns. (1), Západné Tatry Mtns. (1); 9 – Zlatník 1928 (Rozpr. Král. Čes. Společ. Nauk, cl. math.-natur.): Tab. 5, rel. 45-53, Malé Karpaty Mtns.;

Cluster D:

10 – Baláž ined.: Horehronské podolie; 1 – Bernátová & Škovirová 1993 (Biologia): p. 401, rel. 1, Turčianská kotlina Basin; 1 – Bosáčková et al.1974 (In: Štollmann A., ed., Osveta): Tab. 7, rel. 15, Strážovské vrchy Mtns., Súľovské vrchy Hills; 2 – Domin 1932 (Rozpr. II. Tr. Čs. Akad.): p. 9, rel. 1, 2, Malé Karpaty Mtns., Čachtické kopce Hills; 1 – Eliáš et al. 2002 (Rosalia): p. 32, rel. 1, Strážovské vrchy Mtns.; 1 – Fraňo 1971 (Acta Fac. Rer. Natur., Univ. Comen.): p. 27, rel. 11, Východoslovenská rovina Lowland; 5 – Futák 1947 (Sp. Sv. Vojtecha): Tab. 1, rel. 35, 36, p. 86, rel. 7, p. 88, rel. 13, p. 128, rel. 3, Strážovské vrchy Mtns., Kňaží stôl Mt.; 1 – Futák 1960 (PhD. thesis, mscr.): rel. 13, Strážovské vrchy Mtns.; 9 – Háberová et al. 1985 (Final report, mscr.): Tab. 3, rel. 16-24, Slovenský kras Karst; 11 – Chytrý et al. 1997 (Dissert. Bot., J.Cramer Verl.): Tab. 6, rel. 56 (Borská nížina Lowland), Tab. 6, rel. 1-8, 10-12 (Malé Karpaty Mtns.); 2 – Chytrý ined.: Biele Karpaty Mtns. (1), Považský Inovec Mtns. (1); 3 – Jarolímek ined.: Borská nížina Lowland (1), Malé Karpaty Mtns. (2); 1 – Jarolímek & Kliment 2000 (In: Kliment J., ed., ŠOP SR): Tab. 4, rel. 1, Revúcka vrchovina Hills, Drienčanský kras Karst; 4 – Jurko 1951 (SAV): p. 29, rel. 1-3, Tab. 1, rel. 6, Čierna hora Mtns.; 2 – Jurko 1958 (Acta Fac. Rer. Natur. Univ. Comen.): p. 317, rel. 2 (Cerová vrchovina Hills), p. 318, rel. 1 (Rimavská kotlina Basin); 11 – Klika 1930 (Přír. Spol. v M. Ostravě): p. 54, rel. 2, p. 59, rel. 1, p. 60, rel. 1, Tab. 1, rel. 1, Tab. 2, rel. 7-13, Strážovské vrchy Mtns., Súľovské vrchy Hills; 21 – Klika 1929 (Preslia): p. 42, rel.1, p. 45, rel. 9-18, p. 48, rel. 19-28, Turčianska kotlina Basin; 5 – Klika 1931 (Beih. Bot. Centralbl.): p. 378, rel. 36, 38, p. 384, rel. 48-50 (Tríbeč Mtns., Zobor Hills), Tab. 5, rel. 38 (Malé Karpaty Mtns.); 5 – Klika 1937 (Beih. Bot. Centralbl.): Tab. 1, rel. 2, 9, Tab. 2, rel. 1-3, Malé Karpaty Mtns., Brezovské kopce Hills; 12 – Klika 1938 (Beih. Bot. Centralbl.): Tab. 2, rel. 1-12, Burda Hills; 1 – Kliment 1998 (Bull. Slov. Bot. Spoločn.): p. 153, rel. 1, Revúcka vrchovina Hills, Drienčansky kras Karst; 11 – Kliment & Bernátová 2000 (Kmetianum): Tab. 1, rel. 1-11, Turčianska kotlina Basin; 32 – Kliment et al. 2000 (ŠOP SR): Tab. 3, rel. 2-23, Tab. 4, rel. 1-10, Revúcka vrchovina Hills, Drienčanský kras Karst; 7 – Krippel 1954 (Biologia): p. 253, rel. 1, 2 (Podunajská rovina Lowland), p. 257, rel. 1-5 (Východoslovenská rovina Lowland); 30 – Krippelová 1967 (Biol. Pr.): Tab. 8, rel. 1-21, Tab. 10, rel. 1-8, p. 40, rel. 1, Podunajská rovina Lowland; 38 – Maglocký 1979 (Biol. Pr.): Tab. 26, rel. 11, 12, 16, 17, Tab. 27, rel. 1-34, Považský Inovec Mtns.; 1 – Maglocký 1982 (Acta Bot. Slov. ser. A): p. 166, rel. 1, Zemplínske vrchy Hills; 17 – Maglocký ined.: Burda Hills (2), Čierna hora Mtns. (1), Hronská pahorkatina Hills (3), Malé Karpaty Mtns. (4), Podunajská rovina Lowland (3), Strážovské vrchy Mtns. (1), Tríbeč Mtns., Zobor Hills (2), Východoslovenská rovina Lowland (2); 2 – Májovský 1958 (Acta Fac. Rer. Natur. Univ. Comen.): p. 370, rel. 1, 2, Podunajská rovina Lowland; 4 – Májovský & Jurko 1958 (Acta Fac. Rer. Natur. Univ. Comen.): p. 300, rel. 1, 2 (Kremnické vrchy Mtns.), p. 298, rel. 1 (Štiavnické vrchy Mtns.), p. 306, rel. 1 (Veporské vrchy Mtns.); 18 – Miadok 1987 (Acta Fac. Rer. Nat. Univ. Comen.): Tab. 3, rel. 1-18, Slovenský kras Karst; 1 – Michalko 1957 (SAV): p. 49, rel. 1, Vihorlatské vrchy Mtns.; 1 – Michalko & Džatko 1965 (Biol. Pr.): p. 80, rel.1, Nitrianska pahorkatina Hills; 1 – Mráz ined.: Slovenský kras Karst, Zádielska dolina Valley; 2 – Mucina ined.: Chočské vrchy Mtns. (1), Nízke Tatry Mtns. (1); 13 – Nehäusl & Neuhäuslová-Novotná 1964 (Biol. Pr.): Tab. 7, rel. 68-80, Ipeľská pahorkatina; 5 – Neuhauslová-Novotná 1968 (Biol. Pr.): Tab. 4, rel. 14 (Cerová vrchovina Hills), Tab. 4, rel. 13, 15, 17 (Lučenecká kotlina Basin), Tab. 4, rel. 16 (Veporské vrchy Mtns.); 11 – Removčíková 1981 (Master thesis, mscr.): Tab. 4, Slovenský kras Karst; 1 – Ripka ined.: Ipeľská kotlina Basin; 1 – Škovirová 1993 (Bull. Slov. Bot. Spoločn.): p. 59, rel. 1, Turčianská kotlina Basin; 3 – Uhlířová & Bernátová 2002 (Zb. Slov. Nár. Múz. Prír. Vedy): p. 46, rel. 1-3, Turčianska kotlina Basin; 33 – Valachovič ined.: Biele Karpaty Mtns. (3), Cerová vrchovina Hills (5), Ipeľská

kotlina Basin (1), Ipel'ská pahorkatina Hills (1), Krupinská planina Plateau (2), Malé Karpaty Mtns. (9), Ostrôžky Mtns. (4), Pavlovské vrchy Mtns. (1), Pieniny Mtns. (1), Strážovské vrchy Mtns. (4), Štiavnické vrchy Mtns. (1), Vtáčnik Mtns. (1); 2 – Vološčuk 1989: Slovenský kras Karst; 53 – Vozárová 1986 (Zb. Slov. Nár. Múz. Prír. Vedy): Tab. 3, rel. 1-35, 39-56, Tríbeč Mtns., Zobor Hills; 7 – Zlinská 2000 (Acta Environm. Univ. Comen.): Tab. 1, rel. 1-8, Malé Karpaty Mtns.;

Cluster E:

1 – Ambrozek 1989 (Master thesis, mscr.): Tab. 4, rel. 23, Pavlovské kopce Mtns.; 3 – Baláž 1991 (Master thesis, mscr.): Tab. 5, rel. 1-3, Nízke Tatry Mtns.; 1 – Baláž ined.: Zvolenská kotlina Basin; 13 – Bosáčková et al. 1974 (Štollmann, A., ed., Osveta): Tab 10, rel. 1-13, Strážovské vrchy Mtns., Súľovské vrchy Hills; 1 – Fajmonová ined.: Strážovské vrchy Mtns.; 10 – Háberová et al. 1985 (Final report, mscr.): Tab. 5, rel. 1-10, Slovenský kras Karst; 9 – Hadač et al.1997 (Thaiszia): Tab. 1, rel. 1-4, Tab. 2, rel. 1-5, Bukovské vrchy Mtns.; 1 – Chytrý ined.: Štiavnické vrchy Mtns.; 1 – Chytrý et al. 1997 (Dissert. Bot.): Tab. 6, rel. 9, Malé Karpaty Mtns.; 1 – Jarolímek ined.: Cerová vrchovina Hills; 7 – Jurko 1970 (Folia Geobot. Phytotax.): Tab 4, rel. 1-6, Kremnické vrchy Mtns.; 1 Jurko 1971 (Biologia): Skorušinské vrchy Mtns.; 1 – Klika 1930 (Přír. Spol. v M. Ostravě): p. 60, rel. 2, Strážovské vrchy Mtns., Súľovské vrchy Hills; 1 – Kliment 1998 (Bull. Slov. Bot. Spoločn.): p. 156, rel.2, Revúcka vrchovina Hills, Drienčansky kras Karst; 2 – Kliment et al. 2000 (ŠOP SR): Tab. 3, rel. 24, p. 171, rel. 2, Revúcka vrchovina Hills, Drienčanský kras Karst; 2 – Kochjarová 1997 (Bull. Slov. Bot. Spoločn.): p. 59, rel. 10 (Muránska planina Mtns.), p. 59, rel. 9 (Slovenské rudohorie Mtns.); 1 – Kochjarová 1998 (Bull. Slov. Bot. Spoločn.): p. 72, rel. 2, Biele Karpaty Mtns.; 1 – Kochjarová 1998 (PhD. thesis, mscr.): Tab. 3 rel. 3, Revúcka vrchovina Hills, Drienčanský kras Karst; 5 – Kochjarová 2002 (Matthias Belivs. Univ. Proc.): Tab. 2, rel. 1-5, Veľká Fatra Mtns.; 1 – Kochjarová et al. 1997 (Preslia): p. 358, rel 13, Nízke Tatry Mtns.; 8 – Maglocký ined.: Liptovská kotlina Basin (3), Malá Fatra Mtns. (1), Ondavská vrchovina Hills (1), Turčianska kotlina Basin (1), Zvolenská kotlina Basin (1), Žilinská kotlina Basin (1); 2 – Miadok ined.: Poľana Mtns.; 1 – Mucina ined.: Chočské vrchy Mtns.; 2 – Removčíková 1981 (Master thesis, mscr.): Tab. 4, Slovenský kras Karst; 16 – Ružičková 1986 (Biol. Pr.,): Tab. 29, rel. 1-16, Liptovská kotlina Basin; 1 – Sitášová 1999 (Natura Carpatica): p. 81, rel. 7, Slanské vrchy Mtns.; 1 – Sitášová 2000 (Natura Carpatica): p. 140, rel. 15, Čierna hora Mtns.; 1 – Sitášová 2002 (Natura Carpatica): p. 63, rel. 6, Košická kotlina Basin; 1 – Sitášová & Kaduková 1997 (Natura Carpatica): p. 32, rel. 1, Čierna hora Mtns.; 13 – Škodová ined.: Biele Karpaty Mtns.; 5 – Tlusták 1972 (Master thesis, mscr.): Tab. 16, rel. 1, 2, 4, 5, 12, 23, Biele Karpaty Mtns.; 18 – Urbanová 1977 (PhD. thesis, mscr.): Tab 10, rel. 1-18, Kysucká vrchovina Hills; 3 – Valachovič ined.: Cerová vrchovina Hills (1), Malé Karpaty Mtns. (2); 10 – Vicherek 1967 (Biológia): Tab 1, rel. 1-10, Oravská vrchovina Hills;

Cluster F:

1 – Benčaťová & Ujházy 1998 (Techn. Univ.): p. 54, rel. 1, Poľana Mtns.; 1 – David 1999 (Ochr. Prír.): p. 69, rel. 1, Štiavnické vrchy Mtns.; 3 – Futák 1943 (Matica Slovenská): p. 58, rel. 1, 2, p. 59. rel. 1, Kremnické vrchy Mtns.; 1 – Chytrý ined.: Zvolenská kotlina Basin; 1 – Jarolímek ined.: Cerová vrchovina Hills; 3 – Jurko 1951 (SAV): p. 30, rel. 1, 2, p. 31, rel. 1, Čierna hora Mtns.; 1 – Jurko 1958 (Acta Fac. Rer. Natur. Univ. Comen.): p. 316, rel. 1, Cerová vrchovina Hills; 14 – Klika 1938 (Beih. Bot. Centralbl.): Tab. 1, rel. 1-3 (Ipeľská pahorkatina Hills), Tab. 1, rel. 3-14 (Burda Hills); 1 – Kliment et al. 2000 (ŠOP SR): Tab. 3, rel. 1, Revúcka vrchovina Hills; 2 – Kolbek ined.: Pohoronský Inovec Hills; 2 – Korneck 1975 (Mitt. flor.-soz. Arbeitsgem.): Tab. 37, rel. 1, 2, Burda Hills; 1 – Krippel 1954 (Biologia): p. 254, rel. 1, Burda Hills; 1 – Magic 1969 (Report, mscr.): p. 56, rel. 1, Lučenská kotlina Basin; 2 – Magic 1983 (In: Vestenický & Cubonová, eds, ONV Martin): p. 73, 74, Veľká Fatra Mtns.; 1 – Maglocký 1982 (Acta Bot. Slov. ser. A): p. 166, rel. 2, Východoslovenská rovina Lowland; 2 – Maglocký ined.: Ipeľská pahorkatina Hills (1), Štiavnické vrchy Mtns. (1); 14 – Májovský 1954 (Biologia): Tab.1, rel. 1-11, 13, 14 (Košická kotlina Basin), Tab. 1, rel. 12 (Slanské vrchy Mtns.); 17 – Májovský 1955 (Biologia): p. 672, rel. 16 (Čierna hora Mtns.), rel. 13, 15, 17 (Košická kotlina Basin), rel. 3-5 (Levočské vrchy Mtns.), rel. 1, 2 (Popradská kotlina Basin), rel. 6-9, 10, 14 (Slanské vrchy Mtns.), rel. 11, 12 (Vihorlatské vrchy Mtns.); 25 – Májovský & Jurko 1956 (Biologia): Tab. 1, rel. 2, 4, 17 (Košická kotlina Basin), Tab. 1, rel. 1, 5-9, 11-15, 18, 19, 21-25 (Krupinská planina Plateau), Tab. 1, rel. 3, 10, 16, 20 (Zvolenská kotlina Basin); 11 – Májovský & Jurko 1958 (Acta Fac. Rer. Natur. Univ. Comen.): p. 309: Ipeľská pahorkatina Hills (1), Kremnické vrchy Mtns. (2), Pohronský Inovec Hills (2), Štiavnické vrchy Mtns. (1), Veporské vrchy Mtns. (1), Vtáčnik Mtns. (4); 13 – Michalko 1957 (SAV): Tab. 5, rel 1-12, p. 48, rel. 1, Vihorlatské vrchy Mtns.; 3 – Mikyška 1933 (Beih. Bot. Centralbl.): Tab. 1, rel. 10-12, Štiavnické vrchy Mtns.; 2 Mochnacký & Maglocký 1993 (Thaiszia): Tab. 1, rel. 10 (Košická kotlina Basin), Tab. 1, rel. 12 (Zem-

plínske vrchy Hills); 5 – Ripka ined.: Burda Hills (2), Pohoronský Inovec Hills (3); 1 – Sitášová 1999 (Natura Carpatica): p. 81, rel. 6, Slanské vrchy Mtns.; 2 – Sitášová 2000 (Natura Carpatica): p. 138, rel. 10, p. 139, rel. 11, Čierna hora Mtns.; 1 – Šmarda 1961 (SAV): p. 45, rel. 1, Spišsská kotlina Basin; 10 – Valachovič ined.: Kremnické vrchy Mtns. (1), Krupinská planina Plateau (3), Mátra Hills (2), Pohoronský Inovec Hills (1), Štiavnické vrchy Mtns. (2), Visegrádi-hegység Hills (1); 24 – Vozárová 1990 (Zb. Slov. Nár. Múz. Prír. Vedy): Tab. 1: Hronská pahorkatina Hills (9), Ipel'ská pahorkatina Hills (5), Štiavnické vrchy Mtns. (10).

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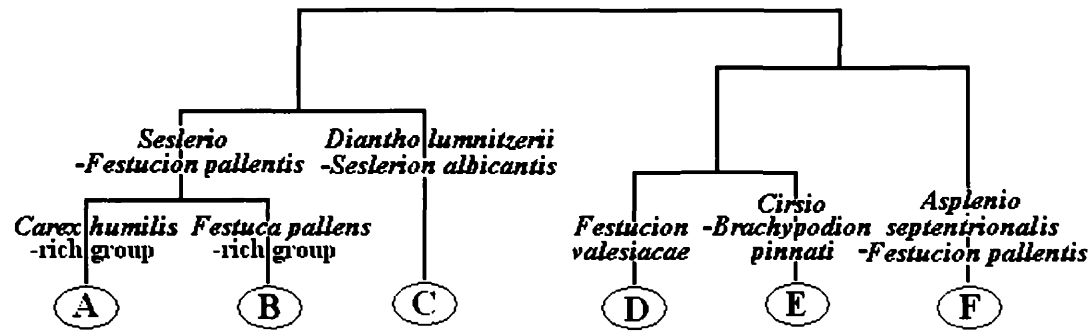
Zu Michálkova & Šibík: *Festuco-Brometea* in Slovakia

Tab. 1: Synoptic table of the groups/alliances of the class *Festuco-Brometea* in Slovakia

Tab. 1: Synoptische Tabelle der Gruppen/Verbände der *Festuco-Brometea* in der Slowakei



		A	B	C	D	E	F
Column		**c (f)**	**c (f)**	**c (f)**	**c (f)**	**c (f)**	**c (f)**
Number of relevés		208	278	191	408	148	165
Average species number		30	29	30	32	44	27
Diagnostic taxa of the groups/alliances							
fv af	*Carex humilis*	**93^{6} (39.9)**	51^{4} (5.6)	80^{5} (27.6)	26^{4} (-)	13^{3} (-)	15^{4} (-)
	Melica ciliata	**51^{2} (29.6)**	38^{2} (19.7)	6^{2} (-)	12^{2} (-)	2^{2} (-)	16^{3} (-)
fv cb	*Scabiosa ochroleuca*	**50^{2} (15.9)**	29^{2} (-)	25^{2} (-)	34^{2} (2.6)	34^{2} (1.5)	19^{2} (-)
Fv	*Campanula sibirica*	**49^{2} (38.6)**	29^{2} (18.6)	4^{2} (-)	6^{2} (-)	2^{2} (-)	1^{2} (-)
Fv	*Pilosella bauhinii*	**47^{2} (21.1)**	18^{2} (-)	23^{2} (-)	20^{2} (-)	24^{2} (-)	25^{2} (-)
sf	*Alyssum montanum*	**46^{2} (36.7)**	14^{2} (-)	12^{2} (-)	10^{2} (-)	- (-)	5^{2} (-)
Fv af	*Allium flavum*	**41^{2} (20.3)**	28^{2} (9.8)	6^{2} (-)	17^{2} (-)	2^{2} (-)	25^{2} (3.7)
sf	*Rhodax canus*	**37^{3} (32.0)**	17^{4} (7.5)	17^{2} (5.6)	3^{3} (-)	1^{2} (-)	- (-)
sf	*Scorzonera austriaca*	**19^{2} (20.6)**	8^{2} (1.8)	15^{2} (13.0)	1^{2} (-)	- (-)	- (-)
	Stipa joannis	**19^{4} (25.8)**	3^{4} (-)	3^{2} (-)	4^{3} (-)	2^{3} (-)	1^{2} (-)
fv af	*Potentilla arenaria*	**71^{4} (20.2)**	**67^{4} (19.9)**	20^{3} (-)	41^{3} (-)	6^{2} (-)	67^{3} (15.1)
sf	*Poa badensis*	**29^{2} (21.0)**	**28^{3} (25.3)**	2^{2} (-)	6^{3} (-)	- (-)	- (-)
fv af	*Stipa pulcherrima*	**20^{3} (19.1)**	**12^{5} (8.4)**	5^{2} (-)	1^{3} (-)	- (-)	10^{4} (3.7)
fv	*Silene otites*	**16^{2} (6.6)**	**22^{2} (0.6)**	5^{2} (-)	8^{2} (-)	1^{2} (-)	8^{2} (-)
Fv	*Pulsatilla grandis*	**16^{2} (12.0)**	**12^{2} (7.4)**	7^{2} (-)	6^{2} (-)	1^{1} (-)	5^{2} (-)
sf FB	*Festuca pallens*	1^{3} (31.6)	**85^{5} (52.4)**	32^{3} (-)	9^{3} (-)	4^{2} (-)	- (-)
sf FB	*Jovibarba globifera ssp.hirta*	57^{2} (26.2)	**61^{3} (36.2)**	26^{2} (-)	9^{2} (-)	5^{2} (-)	- (-)
sf FB	*Sedum album*	13^{2} (-)	**39^{3} (34.5)**	13^{2} (-)	7^{2} (-)	2^{2} (-)	2^{3} (-)
ds sf	*Sesleria albicans*	8^{2} (-)	22^{4} (3.5)	**100^{6} (77.3)**	2^{3} (-)	7^{4} (-)	- (-)
sf	*Anthericum ramosum*	47^{2} (13.6)	44^{3} (13.6)	**68^{3} (31.1)**	13^{3} (-)	16^{3} (-)	8^{2} (-)
ds sf	*Leontodon incanus*	33^{2} (11.7)	31^{3} (10.2)	**67^{3} (21.7)**	23^{2} (-)	39^{2} (-)	1^{2} (-)
	Genista pilosa	16^{2} (-)	5^{3} (-)	**60^{3} (42.6)**	14^{3} (-)	4^{2} (-)	2^{3} (-)
FB	*Anthyllis vulneraria* agg.	38^{2} (10.3)	23^{2} (-)	**53^{3} (24.0)**	17^{2} (-)	39^{2} (9.7)	1^{2} (-)
Fv	*Inula ensifolia*	29^{3} (7.4)	22^{3} (-)	**49^{4} (27.1)**	10^{3} (-)	18^{5} (-)	6^{2} (-)
ds	*Acinos alpinus*	4^{2} (-)	9^{3} (-)	**43^{2} (41.8)**	5^{2} (-)	6^{2} (-)	- (-)
	Pulsatilla slavica	4^{2} (-)	12^{2} (4.2)	**40^{3} (42.5)**	1^{3} (-)	2^{2} (-)	2^{2} (-)
	Galium pumilum agg.	2^{2} (-)	6^{2} (-)	**34^{2} (40.6)**	3^{2} (-)	4^{3} (-)	- (-)
ds	*Phyteuma orbiculare*	1^{2} (-)	4^{2} (-)	**34^{3} (45.1)**	1^{2} (-)	4^{2} (-)	- (-)
ds	*Hippocrepis comosa*	11^{2} (-)	11^{2} (-)	**31^{2} (23.8)**	9^{2} (-)	12^{3} (+2)	- (-)
FB TG	*Bupleurum falcatum*	17^{2} (5.3)	14^{2} (0.6)	**30^{2} (19.8)**	7^{2} (-)	16^{2} (3.2)	- (-)
ds	*Polygala amara*	1^{2} (-)	2^{2} (-)	**27^{2} (40.0)**	1^{2} (-)	3^{2} (-)	- (-)
	Campanula moravica	6^{2} (-)	13^{2} (8.5)	**26^{2} (26.3)**	3^{2} (-)	1^{2} (-)	- (-)
	Asperula tinctoria	3^{2} (-)	8^{3} (1.4)	**25^{3} (27.2)**	3^{2} (-)	6^{2} (-)	2^{2} (-)
Be	*Bromus monocladus*	3^{2} (-)	1^{3} (-)	**24^{3} (35.2)**	3^{4} (-)	1^{2} (-)	- (-)
sf ds	*Biscutella laevigata*	5^{2} (-)	10^{2} (7.4)	**23^{2} (26.3)**	2^{2} (-)	- (-)	- (-)
	Thalictrum minus	11^{2} (5.0)	5^{2} (-)	**21^{2} (21.1)**	3^{2} (-)	1^{2} (-)	8^{2} (1.4)
Be	*Knautia kitaibelii*	- (-)	1^{2} (-)	**18^{3} (23.4)**	4^{2} (-)	11^{2} (10.2)	- (-)
	Platanthera bifolia	- (-)	+^{1} (-)	**14^{2} (30.2)**	+^{2} (-)	3^{2} (2.1)	- (-)
	Thesium alpinum	1^{2} (-)	3^{2} (-)	**14^{2} (26.0)**	+^{2} (-)	3^{2} (-)	- (-)
	Hieracium bupleuroides	1^{2} (-)	5^{2} (5.2)	**14^{2} (23.9)**	+^{3} (-)	- (-)	- (-)
	Hieracium bifidum	- (-)	1^{3} (-)	**13^{2} (29.4)**	+^{2} (-)	- (-)	- (-)
	Kernera saxatilis	- (-)	2^{2} (-)	**13^{2} (28.1)**	1^{2} (-)	- (-)	- (-)
cb	*Tephroseris integrifolia*	- (-)	1^{3} (-)	**13^{2} (28.6)**	- (-)	1^{6} (-)	- (-)
	Epipactis atrorubens	1^{2} (-)	1^{2} (-)	**12^{2} (26.5**	+^{1} (-)	1^{2} (-)	- (-)
Be	*Ophris insectifera*	- (-)	- (-)	**9^{2} (25.1**	1^{2} (-)	- (-)	- (-)
	Senecio umbrosus	- (-)	- (-)	**8^{2} (25.1**	- (-)	1^{2} (-)	- (-)
fv Be	*Eryngium campestre*	26^{2} (0.3)	10^{2} (-)	- (-)	**50^{2} (35.8)**	4^{2} (-)	40^{2} (11.9)
fv	*Festuca valesiaca*	21^{2} (-)	12^{3} (-)	- (-)	**47^{5} (40.0)**	7^{3} (-)	11^{2} (-)
fv af	*Festuca rupicola*	1^{3} (-)	9^{4} (-)	7^{2} (-)	**47^{4} (38.4)**	48^{4} (21.7)	1^{3} (-)
FB SS	*Pilosella officinarum*	24^{2} (2.4)	11^{2} (-)	14^{2} (-)	**37^{2} (23.9)**	18^{2} (-)	7^{2} (-)
Be	*Poa angustifolia*	5^{2} (-)	4^{3} (-)	1^{2} (-)	**30^{3} (32.1)**	15^{2} (1.7)	9^{3} (-)
	Leontodon autumnalis	+^{2} (-)	+^{2} (-)	1^{2} (-)	**21^{3} (37.3)**	- (-)	- (-)
Fv	*Achillea collina*	12^{2} (2.3)	2^{2} (-)	2^{2} (-)	**20^{2} (20.8)**	12^{2} (2.6)	4^{2} (-)
	Convolvulus arvensis	- (-)	4^{1} (-)	1^{2} (-)	**18^{2} (25.0)**	8^{2} (0.9)	6^{2} (-)
fv af	*Phleum phleoides*	6^{2} (-)	9^{2} (-)	1^{5} (-)	**18^{3} (11.6)**	12^{2} (0.2)	19^{2} (9.0)
	Trifolium campestre	1^{2} (-)	3^{2} (-)	1^{2} (-)	**17^{2} (21.9)**	4^{2} (-)	14^{2} (9.2)
	Festuca pseudovina	2^{6} (-)	+^{7} (-)	- (-)	**16^{6} (30.4)**	2^{3} (-)	1^{6} (-)
fv Fv	*Adonis vernalis*	+^{2} (-)	1^{3} (-)	- (-)	**11^{2} (23.0)**	3^{2} (-)	3^{3} (-)
	Carduus nutans	2^{1} (-)	3^{2} (-)	- (-)	**10^{2} (20.3)**	- (-)	1^{2} (-)
fv af	*Koeleria macrantha*	37^{2} (5.6)	31^{2} (-)	3^{3} (-)	**42^{3} (15.2)**	9^{3} (-)	**49^{3} (14.3)**
fv	*Botriochloa ischaemum*	27^{3} (9.6)	7^{2} (-)	- (-)	**28^{4} (17.0)**	4^{3} (-)	**35^{3} (15.5)**
MA	*Plantago lanceolata*	11^{2} (-)	6^{2} (-)	6^{2} (-)	**36^{2} (26.3)**	**48^{2} (24.4)**	5^{2} (-)
cb Be	*Brachypodium pinnatum*	4^{2} (-)	7^{3} (-)	14^{3} (-)	12^{3} (-)	**93^{6} (68.9)**	2^{2} (-)
Be	*Pimpinella saxifraga*	14^{2} (-)	10^{2} (-)	36^{2} (6.3)	39^{2} (14.9)	**74^{3} (34.9)**	4^{2} (-)
FB	*Plantago media*	4^{2} (-)	3^{2} (-)	22^{2} (1.6)	30^{2} (15.2)	**69^{3} (41.5)**	2^{2} (-)
FB	*Lotus corniculatus*	4^{2} (-)	6^{2} (-)	25^{2} (3.4)	29^{1} (12.6)	**65^{2} (36.8)**	5^{2} (-)
fv MA	*Achillea millefolium* agg.	2^{1} (-)	2^{2} (-)	1^{2} (-)	17^{3} (8.7)	**60^{3} (50.3)**	1^{2} (-)
Be MA	*Briza media*	1^{2} (-)	2^{3} (-)	18^{2} (7.5)	8^{3} (-)	**60^{3} (51.8)**	- (-)
	Carlina acaulis	2^{1} (-)	4^{2} (-)	24^{2} (13.1)	8^{2} (-)	**57^{2} (45.6)**	- (-)
FB	*Linum catharticum*	3^{2} (-)	3^{2} (-)	23^{2} (10.0)	12^{2} (-)	**57^{3} (42.7)**	1^{1} (-)
FB	*Viola hirta*	8^{2} (-)	8^{2} (-)	29^{2} (15.4)	8^{2} (-)	**55^{2} (38.9)**	1^{1} (-)
MA	*Leucanthemum vulgare*	- (-)	7^{2} (-)	25^{2} (15.3)	7^{2} (-)	**53^{2} (42.0)**	1^{2} (-)
cb FB	*Agrimonia eupatoria*	2^{1} (-)	2^{1} (-)	- (-)	13^{2} (6.9)	**49^{2} (44.4)**	5^{2} (-)
	Salvia verticillata	7^{2} (-)	4^{2} (-)	9^{2} (-)	10^{2} (-)	**49^{3} (40.0)**	4^{2} (-)
Be FB	*Securigera varia*	7^{2} (-)	15^{2} (-)	6^{2} (-)	24^{2} (9.9)	**49^{3} (27.6)**	10^{2} (-)
Be	*Thymus pulegioides*	- (-)	1^{3} (-)	4^{2} (-)	5^{3} (-)	**47^{2} (50.1)**	4^{4} (-)
cb FB	*Carlina vulgaris*	8^{2} (-)	4^{2} (-)	5^{2} (-)	16^{2} (8.6)	**41^{2} (31.2)**	1^{2} (-)
Be FB	*Trifolium montanum*	- (-)	3^{2} (-)	- (-)	7^{3} (0.5)	**39^{3} (41.9)**	4^{1} (-)
MA	*Leontodon hispidus* agg.	3^{1} (-)	1^{2} (-)	15^{2} (5.5)	12^{2} (3.3)	**38^{3} (30.8)**	2^{1} (-)
	Daucus carota	3^{2} (-)	1^{2} (-)	- (-)	12^{2} (9.1)	**38^{2} (37.3)**	1^{2} (-)
MA TG	*Dactylis glomerata*	- (-)	- (-)	- (-)	9^{2} (5.4)	**37^{2} (41.8)**	2^{2} (-)
MA	*Trifolium pratense*	- (-)	- (-)	- (-)	8^{2} (4.3)	**36^{2} (43.2)**	- (-)
FB TG	*Galium mollugo* agg.	11^{2} (2.5)	9^{2} (-)	3^{3} (-)	8^{2} (-)	**30^{3} (24.1)**	1^{1} (-)
FB	*Knautia arvensis*	+^{2} (-)	1^{2} (-)	- (-)	3^{2} (-)	**30^{2} (41.7)**	2^{1} (-)
MA	*Festuca pratensis*	1^{2} (-)	- (-)	- (-)	3^{2} (-)	**29^{2} (44.0)**	- (-)
	Fragaria vesca	1^{2} (-)	3^{2} (-)	2^{2} (-)	3^{2} (-)	**29^{2} (37.2)**	3^{2} (-)

FB	*Ononis spinosa*	- (-)	- (-)	1^2 (-)	8^2 (7.5)	**28^2 (33.8)**	- (-)
FB MA	*Arrhenatherum elatius*	2^2 (-)	$+^2$ (-)	1^2 (-)	14^3 (14.9)	**26^3 (24.4)**	2^2 (-)
	Carex caryophyllea	3^3 (-)	3^3 (-)	2^3 (-)	17^3 (18.0)	**26^3 (20.2)**	- (-)
	Primula veris	2^2 (-)	1^2 (-)	4^2 (-)	4^2 (-)	**26^3 (33.0)**	1^2 (-)
Be	*Carex flacca*	- (-)	$+^2$ (-)	1^2 (-)	2^3 (-)	**25^3 (41.3)**	- (-)
MA	*Agrostis capillaris*	- (-)	- (-)	- (-)	7^4 (6.5)	**25^3 (32.9)**	1^3 (-)
MA	*Anthoxanthum odoratum*	- (-)	1^3 (-)	- (-)	5^4 (3.8)	**23^3 (32.1)**	- (-)
	Betonica officinalis	1^2 (-)	3^2 (-)	5^2 (0.4)	2^2 (-)	**23^2 (30.6)**	2^1 (-)
Be	*Carex montana*	- (-)	- (-)	- (-)	1^3 (-)	**22^3 (42.9)**	- (-)
	Clinopodium vulgare	2^2 (-)	4^2 (-)	- (-)	2^2 (-)	**22^2 (29.5)**	2^2 (-)
MA	*Vicia cracca*	1^2 (-)	2^2 (-)	1^2 (-)	1^2 (-)	**22^2 (35.7)**	1^1 (-)
MA	*Festuca rubra*	- (-)	$+^2$ (-)	1^2 (-)	3^3 (0.2)	**20^3 (32.4)**	- (-)
	Filipendula vulgaris	$+^2$ (-)	1^4 (-)	- (-)	6^2 (2.2)	**20^3 (23.6)**	7^2 (2.5)
MA	*Veronica chamaedrys*	$+^2$ (-)	- (-)	- (-)	6^2 (7.2)	**20^2 (26.7)**	1^2 (-)
cb MA	*Jacea pratensis* agg.	1^2 (-)	- (-)	1^2 (-)	6^2 (6.1)	**19^3 (25.2)**	1^1 (-)
cb FB	*Polygala major*	1^2 (-)	3^2 (-)	3^2 (-)	5^2 (1.6)	**19^2 (22.5)**	1^2 (-)
cb	*Ranunculus polyanthemos*	- (-)	1^3 (-)	- (-)	4^2 (2.0)	**18^2 (29.8)**	- (-)
FB	*Veronica teucrium*	$+^2$ (-)	1^2 (-)	3^2 (-)	3^2 (-)	**17^2 (24.7)**	2^2 (-)
MA	*Acetosa pratensis*	- (-)	- (-)	- (-)	1^2 (-)	**16^2 (31.8)**	1^2 (-)
FB	*Campanula glomerata*	1^2 (-)	2^2 (-)	2^2 (-)	1^2 (-)	**16^2 (26.2)**	- (-)
cb	*Cirsium pannonicum*	- (-)	1^4 (-)	12^3 (17.3)	$+^2$ (-)	**16^3 (23.8)**	- (-)
	Euphrasia rostkoviana	2^2 (-)	4^2 (0.3)	4^2 (0.5)	1^2 (-)	**16^2 (24.2)**	- (-)
	Tragopogon orientalis	2^2 (-)	1^2 (-)	- (-)	2^2 (-)	**16^2 (27.1)**	- (-)
MA	*Trisetum flavescens*	- (-)	- (-)	- (-)	$+^2$ (-)	**16^3 (36.6)**	- (-)
MA	*Ranunculus acris*	- (-)	- (-)	- (-)	2^2 (-)	**15^2 (29.6)**	- (-)
	Alchemilla sp. div.	- (-)	- (-)	- (-)	1^2 (-)	**14^2 (32.1)**	- (-)
	Danthonia decumbens	- (-)	- (-)	- (-)	1^2 (-)	**14^3 (32.2)**	- (-)
	Ononis arvensis	- (-)	- (-)	- (-)	1^2 (-)	**13^2 (29.5)**	1^1 (-)
	Gentiana cruciata	$+^1$ (-)	$+^2$ (-)	- (-)	1^2 (-)	**13^2 (28.0)**	- (-)
MA	*Rhinanthus minor*	$+^1$ (-)	$+^2$ (-)	- (-)	2^2 (-)	**12^3 (22.7)**	2^2 (-)
	Carex tomentosa	$+^2$ (-)	$+^5$ (-)	- (-)	$+^5$ (-)	**11^2 (29.1)**	- (-)
	Trifolium medium	- (-)	- (-)	- (-)	1^2 (-)	**11^3 (27.4)**	- (-)
	Viola canina	- (-)	- (-)	- (-)	$+^2$ (-)	**11^2 (30.1)**	- (-)
af	*Festuca pseudodalmatica*	5^2 (-)	2^6 (-)	- (-)	1^4 (-)	- (-)	**98^6 (90.9)**
fv Fv	*Thymus pannonicus*	35^2 (10.5)	13^2 (-)	2^3 (-)	30^3 (9.1)	8^2 (-)	**53^3 (25.0)**
fv FB	*Acinos arvensis*	22^2 (-)	25^2 (1.5)	5^2 (-)	25^2 (3.3)	7^2 (-)	**51^2 (25.0)**
af	*Arenaria leptoclados*	6^2 (-)	15^2 (3.5)	- (-)	9^2 (-)	1^2 (-)	**51^2 (42.3)**
fv FB	*Trifolium arvense*	2^2 (-)	1^2 (-)	- (-)	14^3 (6.8)	- (-)	**49^2 (47.5)**
fv FB	*Stachys recta*	37^2 (12.2)	32^2 (8.1)	6^2 (-)	17^2 (-)	14^2 (-)	**46^2 (18.2)**
af FB	*Galium glaucum*	26^2 (7.0)	17^2 (-)	17^2 (-)	13^2 (-)	2^3 (-)	**43^2 (22.4)**
Fv FB	*Potentilla argentea*	- (-)	1^2 (-)	- (-)	22^2 (20.3)	3^2 (-)	**40^2 (31.6)**
FB SS	*Sedum acre*	18^2 (4.7)	15^2 (-)	5^2 (-)	13^2 (-)	2^2 (-)	**35^3 (22.2)**
	Verbascum austriacum	11^1 (0.9)	5^2 (-)	3^2 (-)	8^2 (-)	6^2 (-)	**34^2 (28.1)**
	Achillea nobilis	22^2 (11.5)	3^2 (-)	- (-)	15^2 (5.6)	1^2 (-)	**34^2 (24.9)**
	Hylotelephium maximum	- (-)	- (-)	- (-)	$+^2$ (-)	- (-)	**30^2 (30.7)**
af	*Cruciata pedemontana*	- (-)	1^2 (-)	- (-)	7^2 (3.2)	- (-)	**28^2 (36.9)**
af Fv	*Linaria genistifolia*	13^2 (3.5)	9^2 (-)	1^2 (-)	12^2 (2.7)	1^2 (-)	**26^2 (19.3)**
fv	*Elytrigia intermedia*	1^2 (-)	2^3 (-)	- (-)	5^2 (-)	3^2 (-)	**24^3 (30.6)**
	Anthemis tinctoria	2^2 (-)	1^2 (-)	- (-)	4^3 (-)	2^2 (-)	**24^2 (34.1)**
af	*Carduus colinus*	7^1 (1.8)	4^2 (-)	- (-)	4^2 (-)	1^1 (-)	**23^2 (28.9)**
	Cerastium brachypetalum agg.	1^2 (-)	4^2 (-)	- (-)	3^2 (-)	- (-)	**22^3 (31.6)**
	Leopoldia comosa	- (-)	1^2 (-)	- (-)	6^2 (5.5)	1^2 (-)	**21^2 (29.1)**
	Bromus hordeaceus	- (-)	- (-)	- (-)	8^3 (10.1)	- (-)	**19^2 (25.9)**
af FB	*Melica transsilvanica*	- (-)	1^2 (-)	1^3 (-)	2^2 (-)	3^2 (-)	**18^2 (31.3)**
af	*Cleistogenes serotina*	10^2 (11.3)	1^2 (-)	- (-)	$+^2$ (-)	- (-)	**17^4 (23.2)**
	Verbascum phoeniceum	$+^2$ (-)	1^2 (-)	- (-)	5^2 (5.2)	- (-)	**16^2 (24.8)**
	Filago arvensis	- (-)	$+^2$ (-)	- (-)	1^2 (-)	- (-)	**16^2 (32.3)**
	Asplenium septentrionale	- (-)	1^2 (-)	- (-)	$+^2$ (-)	- (-)	**15^2 (31.2)**
	Petrorhagia prolifera	$+^2$ (-)	2^2 (-)	- (-)	8^2 (11.3)	1^2 (-)	**15^2 (17.2)**
	Steris viscaria	- (-)	$+^2$ (-)	- (-)	5^4 (6.9)	2^2 (-)	**14^2 (19.9)**
af	*Inula oculus-christi*	- (-)	1^2 (-)	- (-)	2^2 (-)	- (-)	**13^3 (24.9)**
	Riccia ciliata (E_0)	- (-)	- (-)	- (-)	$+^2$ (-)	- (-)	**13^2 (32.8)**
	Valerianella dentata	1^2 (-)	1^2 (-)	- (-)	- (-)	- (-)	**13^2 (31.1)**
Fv	*Lactuca viminea*	2^2 (-)	1^2 (-)	- (-)	3^2 (1.6)	- (-)	**12^2 (19.4)**
	Myosotis ramosissima	$+^3$ (-)	2^3 (-)	- (-)	4^2 (3.2)	- (-)	**12^2 (19.0)**
	Viola tricolor agg.	- (-)	$+^2$ (-)	- (-)	$+^2$ (-)	1^1 (-)	**12^2 (29.3)**
af	*Poa pannonica*	- (-)	$+^3$ (-)	- (-)	2^6 (-)	- (-)	**11^3 (26.4)**
	Prunus fruticosa	- (-)	1^2 (-)	- (-)	- (-)	- (-)	**10^2 (26.5)**
af	*Orlaya grandiflora*	- (-)	1^2 (-)	- (-)	$+^2$ (-)	- (-)	**8^3 (21.4)**
	Allium vineale	- (-)	- (-)	- (-)	$+^1$ (-)	1^2 (-)	**6^2 (19.6)**
fv	*Erysimum crepidifolium*	- (-)	- (-)	- (-)	- (-)	- (-)	**5^2 (22.0)**
Other taxa:							
	Teucrium montanum	81^3 (40.2)	43^3 (6.7)	79^3 (36.1)	12^2 (-)	5^3 (-)	1^2 (-)
fv FB	*Tithymalus cyparissias*	70^2 (3.5)	67^2 (1.6)	63^2 (-)	62^3 (-)	69^2 (2.5)	67^2 (0.9)
sf Fv	*Seseli osseum*	68^2 (23.7)	55^2 (15.1)	43^2 (2.2)	24^2 (-)	3^2 (-)	50^3 (7.5)
FB	*Helianthemum grandiflorum* agg.	51^2 (11.8)	50^2 (7.5)	64^3 (5.6)	23^2 (-)	39^2 (-)	1^2 (-)
fv af	*Thymus praecox*	44^2 (11.3)	42^3 (10.1)	44^3 (10.4)	32^3 (0.5)	4^2 (-)	10^3 (-)
TG	*Vincetoxicum hirundinaria*	37^2 (15.8)	28^3 (9.2)	46^2 (23.7)	5^2 (-)	12^2 (-)	10^2 (-)
	Erysimum odoratum	21^2 (9.9)	19^2 (8.9)	17^2 (4.6)	11^2 (-)	5^2 (-)	- (-)
Fv FB	*Artemisia campestris*	20^2 (14.4)	13^2 (4.8)	1^2 (-)	7^2 (-)	2^2 (-)	18^2 (9.4)
	Asplenium ruta-muraria	16^2 (11.7)	19^2 (17.7)	15^2 (9.4)	1^2 (-)	- (-)	- (-)
fv Fv	*Acosta rhenana* agg.	25^2 (1.3)	20^2 (-)	4^2 (-)	37^2 (20.8)	6^2 (-)	32^2 (7.1)
FB	*Arabis hirsuta*	12^2 (7.4)	4^2 (-)	9^2 (2.8)	7^2 (-)	13^2 (7.7)	1^2 (-)
fv FB	*Dorycnium herbaceum*	25^3 (15.1)	4^2 (-)	21^3 (10.1)	12^3 (-)	11^4 (-)	7^2 (-)
	Globularia punctata	26^2 (12.3)	14^2 (-)	31^3 (17.6)	13^3 (-)	3^2 (-)	- (-)
FB	*Sanguisorba minor*	53^2 (5.6)	43^2 (-)	52^2 (4.7)	50^2 (5.9)	55^2 6.6)	16^2 (-)
fv Be	*Teucrium chamaedrys*	68^3 (11.0)	40^3 (-)	61^3 (5.4)	56^3 (2.4)	48^3 (-)	53^3 (-)
Be FB	*Linum tenuifolium*	29^2 (19.2)	12^2 (-)	26^2 (15.6)	8^2 (-)	4^2 (-)	- (-)
TG	*Origanum vulgare*	21^2 (14.1)	10^2 (-)	8^2 (-)	2^2 (-)	21^2 (11.3)	13^2 (3.0)
fv FB	*Salvia pratensis*	31^2 (4.0)	15^2 (-)	25^2 (-)	30^2 (5.1)	42^2 (11.9)	18^2 (-)
fv FB	*Medicago falcata*	21^2 (0.1)	9^2 (-)	5^2 (-)	30^2 (14.3)	42^3 (18.1)	17^2 (-)
fv FB	*Stipa capillata*	15^2 (9.5)	10^3 (1.1)	- (-)	15^3 (13.0)	- (-)	4^2 (-)
sf af	*Allium senescens* ssp. *montanum*	10^2 (-)	16^3 (6.6)	24^2 (14.6)	3^3 (-)	7^3 (-)	15^2 (6.0)
sf	*Dianthus praecox*	4^2 (-)	17^3 (19.7)	13^2 (9.5)	3^2 (-)	2^2 (-)	- (-)
	Erysimum wittmannii	1^2 (-)	11^2 (11.7)	19^2 (25.6)	$+^2$ (-)	1^2 (-)	1^2 (-)
sf	*Cyanus triumfettii*	7^2 (-)	17^2 (17.2)	7^2 (-)	6^2 (-)	1^1 (-)	6^2 (-)
FB SS	*Sedum sexangulare*	19^2 (-)	22^2 (1.9)	5^2 (-)	28^2 (12.2)	11^2 (-)	25^3 (5.6)
fv	*Dianthus carthusianorum* agg.	14^2 (-)	17^2 (-)	19^2 (-)	16^2 (-)	34^2 (13.0)	22^2 (2.6)
fv Be	*Colymbada scabiosa* agg.	14^2 (-)	5^2 (-)	19^3 (2.8)	15^2 (-)	32^3 (14.4)	8^2 (-)
FB	*Potentilla heptaphylla*	20^3 (-)	8^2 (-)	47^2 (24.5)	20^2 (-)	41^2 (16.7)	4^2 (-)
FB	*Galium verum*	3^2 (-)	5^2 (-)	7^2 (-)	31^2 (21.2)	51^2 (29.0)	12^2 (-)
fv	*Achillea pannonica*	5^2 (-)	5^2 (-)	- (-)	10^2 (9.5)	4^2 (-)	11^2 (6.7)
Be FB	*Bromus erectus*	- (-)	$+^2$ (-)	6^2 (-)	12^5 (16.6)	15^5 (12.7)	1^2 (-)

Abbreviations: **c** – constancy (%), **f** – fidelity (*phi* coeff. x 100), **FB** – *Festuco-Brometea*, **SS** – *Sedo-Sclerantethea*, **MA** – *Molinio-Arrhenatheretea*, **TG** – *Trifolio-Geranietea sanguinei*, **Fv** – *Festucetalia valesiaceae*, **Be** – *Brometalia erecti*, **sf** – *Seslerio-Festucion glaucae*, **ds** – *Diantho lumnitzeri-Seslerion albicantis*, **fv** – *Festucion valesiacae*, **af** – *Asplenio septentrionalis-Festucion pallentis*, **cb** – *Cirsio-Brachypodion pinnati*.